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MASTER

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THE LASL/UNM SOLAR ECONOMIC PERFORMANCE CODE:
A BASIC PRIMER

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ABSTRACT

The LASL/UNM solar economic performance code (model) has been developed to assist in the evaluation of market potential for residential passive solar heating systems on a nationwide basis. Components of the model can be divided into three major categories: inputs, methodology, and output. Each of these categories are briefly described in this paper.

## I. INTRODUCTION

The LASL/UNM solar economic performance code is one of few tools capable of evaluating passive design measures. At present this model allows the evaluation of three general passive designs (two thermal storage walls and a direct gain design) for 223 locations in the contiguous United States [8]. Each of the designs may be evaluated with and without the night insulation option. The major components of the model can be divided into inputs, methodology and outputs.

## 2. INPUTS DESCRIPTION

The inputs to the LASL/UNM code can be divided into three types: fixed, variable, and user specified. The fixed inputs have been specified for 223 SOLMET locations within the contiguous United States. This set of inputs is constant and values may not be overriden by the user. The variable inputs have default values which may be overriden by the user. The last set of inputs must be specified by the user prior to exercising the model.

### 2.1 Fixed Inputs

Table 1 lists the inputs which have been fixed for the LASL/UNM code. The elements are briefly discribed below, with references given.

LCR The load collector ratios are the result of a simplified correlation procedure developed from hour-by-hour thermal network models. They are used to estimate the solar performance of each of the following designs: Trombe wall, water wall and direct gain--both with and without a night insulation option (R=9). The Trombe wall design assumes 18" of mass (1.5 $ft^3$ mass/$ft^2$ appature). The LCR's for the Trombe wall have been shown to be nearly identical for all variations of thickness from 12" to 18" in most United States locations. The water wall design assumes 12" tubes. The direct gain design assumes 1.5 $ft^3$ of mass for every 1.0 $ft^2$ of south-facing glass.

TABLE 1

FIXED INPUTS

| | |
|---|---|
| LCR - LOAD COLLECTOR RATIOS | Developed by the Solar Energy Group at LASL [1] |
| DEGREE DAYS | Average annual heating degree days [8] |
| HOUSE DESIGNS | Three designs furnished by TEA [7] |
| HEAT LOSS FACTORS | Developed from NCSBSC Code [6] |
| FUEL PRICES | 1979 prices from AGA and DOE [4] |
| CONSTRUCTION COST ADJUSTMENTS | Indices developed from Means [3] |

Degree Days A 65°F heating degree day base is used in the LASL/UNM code [8].

House Designs The three house designs are of TEA origin. The first is a one-story slab on grade home. The second is a two-story home built over a full unheated basement. The third house is built over a partially heated basement. Complete architectural renderings are available in [7].

Heat Loss Factors The home space heating loads are computed using allowable heat loss factors (Btu/DD/$ft^2$res) for the three designs. The National Conference of States on Building Codes and Standards (NCSBCS) model code was used to develop the heat loss estimation procedure. The crack-length method is used to estimate convective losses. Maximum allowable U-values are used to calculate the conductive losses. Publication of the procedure is forthcoming [6].

Fuel Prices Fuel prices for the 1979 base year were obtained from the American Gas Association and DOE [4]. Some of the 223 SOLMET data base locations are not included in these three sources and substitute cities were used. In some cases the utility was contacted directly for fuel price data. Publication of the procedure and 1979 fuel prices used in the LASL/UNM code is forthcoming [4].

Construction Cost Adjustments Construction cost adjustments are specified for each of the six designs. Weights for each of twelve building materials and labor groupings [3] were assigned to each system; local cost indices for each grouping were used to calculate the cost index for each system. More detail on the construction cost adjustment calculations and their specific values is available in [6].

### 2.2 Variable Inputs

Table 2 identifies the inputs which may be varied by the user. The printing indices control the type and quantity of output. The other variable inputs influence the outcome of the economic evaluation. The default values for these variables will be used when the model is exercised unless the user overrides them. A detailed description of each of the inputs in this group can be found in the user's manual [2].

### 2.3 User Specified Inputs

Table 3 shows the inputs which must be specified by the user. A subset of locations is chosen and specified by a set of identification numbers. Any combination of fuel types and system designs may be specified for analysis. In addition, the user must specify the house design, the maximum collector area, and the fixed and variable cost values. Any one set of specifications constitutes a "case". Up to six cases may be included in one model run.

TABLE 2

| VARIABLE INPUTS | DEFAULT VALUE |
|---|---|
| **PRINTING INDICES** | |
| Input Data (2 flags) | 0* |
| Intermediate Calculations (4 flags) | 0* |
| Summary Tables (2 flags) | 1* |
| **CONSTRAINTS** | |
| Simple Payback (years) | 20 |
| Down Payment Recovery (years) | 15 |
| Collector Area | 1* |
| **FINANCIAL PARAMETERS** | |
| Solar System Life (years) | 30 |
| ICA (flag on current/annualized price usage) | 2* |
| IREAL (flag on current/annualized computation) | 1* |
| Discount Rate (Real) | .035 |
| Interest Rate (Real) | .035 |
| Annual Inflation Rate | .06 |
| Fuel Escalation Rates (Real) | |
| Natural Gas | .04 |
| Heating Oil | .04 |
| Electricity | .02 |
| Operating & Maintenance Rate | .01 |
| Property Tax Rate | .02 |
| Federal, State & Local Tax Bracket | .30 |
| Down Payment Rate | .20 |
| Resale Value Rate | .00 |
| **GOVERNMENT INCENTIVES** | |
| Government Incentive Tier 1 Limit (\$) | 2000.00 |
| Government Incentive Tier 2 Limit (\$) | 8000.00 |
| Tier 1 Rate | .00 |
| Tier 2 Rate | .00 |
| Total Cost Applicable to Incentives (percent) | 1.00 |
| **DESIGN PARAMETERS** | |
| U-value of Solar System Glazing | .09 |
| Size of Residence 1 ($ft^2$) | 1536 |
| Size of Residence 2 ($ft^2$) | 1925 |
| Size of Residence 3 ($ft^2$) | 2093 |

*These parameter values serve as flags in the LASL/UNM code. See [8] for further explanation.

## 3. METHODOLOGY

The LASL/UNM model employs a variant of life cycle cost analysis. For any one passive design a series of home heating system options are evaluated from 5% to 100% solar savings fraction in 5% increments. The optimal system is defined as the one which minimizes the delivered cost of heat. Figure 1 gives an indication of the way the model is structured.

The first portion of the code is concerned with specification of inputs and calculation of certain economic parameters. The fixed inputs and the default values of the variable inputs are read, along with the user specified inputs and any modifications to the variable inputs. Fixed charge rates (FCR) and present worth factors (PWF's) are calculated. Auxiliary fuel prices are calculated in both current and annualized dollars.

After all economic parameters are defined, solar collector areas are calculated from the LCR ratios and home heating loads. The solar system cost is computed for each fraction by using this collector area and the relevant variable cost. Solar cost is annualized by employing the FCR's and PWF's. Payback measures are calculated by comparing the dollar value of the displaced conventional fuel with either the cost of the system or the down payment.

Optimal system size is defined as the system which minimizes the delivered cost of heat.

TABLE 3

USER SPECIFIED INPUTS

REQUIRED

FUEL TYPES
1. Number of Fuel Types to be Examined
2. Fuel Types Indices to be Examined

LOCATIONS (CITIES)
1. Number of Cities to be Evaluated
2. City Indices (ID Number) to be Evaluated

CASE SPECIFICS
1. System Type(s) (ISOL)
2. House Type(s) (IHS)
3. Collector Area Constraint Value (CO)
4. Fixed System Cost (FC)
5. Variable System Cost (VC)

OPTIONAL

MODIFICATIONS TO VARIABLE INPUTS
1. Number of Inputs to be Modified
2. Input Indices to be Modified
3. Desired Value for Each Input to be Modified

Both unconstrained and constrained optimization is done. If the design is competitive in 1979, an option can be employed to give a detailed year-by-year cash flow analysis of the optimal system.

The cost goals portion of the model uses the conventional fuel price to calculate the maximum allowable solar cost which would generate a zero net present value of dollar savings.

## 4. OUTPUT OPTIONS

There are eight output options which fit into the three groups (printing indices) shown in Table 2; each is activated by defining the value of the appropriate printing index to be 1.

### 4.1 Input Data

Two sets of model inputs can be printed out. The first is a listing of all of the cities in the region of interest; the second is a listing of all modified parameters, both general and economic, to be used in the analysis.

### 4.2 Intermediate Calculations

The third printing index controls the listing of both current and annualized fuel prices. Current prices are listed for 1979 and 1980 through 2020 in five year increments. Annualized prices are given for 1979 through 1990 in one year increments.

The total cost table (fourth printing index) shows the location, passive solar design, auxiliary fuel, year of analysis, degree days (65°F base), heat loss factor, home heating load, and the variable system cost. The rest of the table shows, by solar fraction, collector area (CA), load to collector ratio (LCR), energy displaced by the collector (SLS), total system cost (TC), average annualized solar cost (TC), average annualized solar cost in $/10^6$Btu (ASC), average annualized auxiliary fuel cost in $/10^6$Btu (ACC), delivered cost of heat in $/10^6$Btu (DCH), net present value--1979 $(NPV), and two measures of system payback--years to simple payback and years to recover down payment. The optimal system size is also shown. The first table to appear in the output is for an unconstrained optimization, next the same information is printed for the constrained optimum.

The next two tables are for cost goals and cash flow information (fifth and sixth indices). The cost goal table reflects the maximum feasible variable and total system cost by solar fraction. The cash flow table gives detailed yearly financial information for the optimal system in 1979.

### 4.3 Summary Information

The summary information is of two types. The first table (seventh printing index) summarizes twelve characteristics (e.g., solar fraction and savings) for each locale included in one case. This table appears at the end of each case being examined. In the second summary table (eighth index), only six characteristics are displayed for each case. This final summary allows the user to easily compare results from one location to another. Examples of the LASL/UNM model output can be found in [2]. Other analysis stemming from use of this code has been previously reported in [5].

## 5. SUMMARY

The LASL/UNM solar economic performance model currently resides on an IBM-360/67 computer at the University of New Mexico. It can be exercised for a small subset of SOLMET locations on the timesharing interactive system, and for whole regions on the batch system. The documented model is currently available through either the Solar Energy Research Institute (SERI) or the Energy Systems and Economic Analysis Group (LASL). Information reflecting the full model output for all 223 locales is available as [6].

A series of modifications to the code described here is planned. The incentives portion of the costing routine will be changed to reflect current and proposed passive solar tax credits. Information on current housing stock and projected starts will be added. The capability to handle mixed systems is to be made available as an option. A passive-conservation optimization routine is to be added.

## 7. REFERENCES


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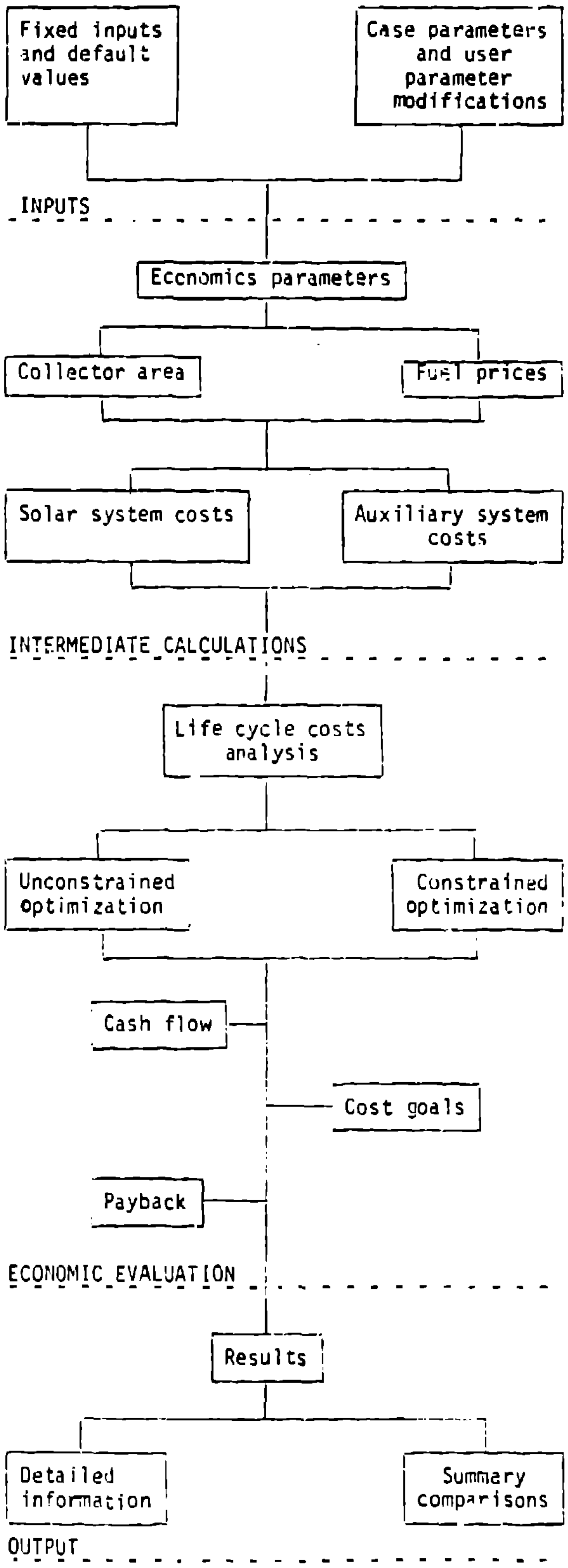


Figure 1: LASL/UNM Solar Economic Performance Code Structure